Leading by example, saving energy and taxpayer dollars in federal facilities

New and emerging lighting technologies, such as fiber optic lighting systems, can reduce energy and maintenance costs while maintaining lighting quality.

Lighting Demonstrations in Defense Commissary Freezer Systems

New lighting technology reduces energy consumption while maintaining effective illumination

The Defense Commissary Agency operates a worldwide chain of commissaries providing groceries to military personnel, retirees and their families. Patrons save an average of more than 30 percent on their purchases compared to commercial prices, which is a valued part of military pay and benefits. For this reason, keeping costs low is paramount to the Defense Commissary Agency

Vertical reach-in freezer display cases with fiber optic lighting system.

Commissaries, like most food sales facilities, are some of the most energy intensive buildings. The largest energy consumer is usually the refrigeration system, which can account for half of the total annual energy consumption. The second largest energy consumer is usually the lighting system. Together, these two account for significant annual operating costs. Reducing these energy costs is a major concern to the Defense Commissary Agency.

Commissaries have extended customer business hours compared to most buildings. During the day, patrons keep the front of the building busy. Deliveries keep the back of the building busy as trucks continuously arrive; products are unloaded, and items are placed in interim storage. After customer hours, the shelves are restocked with the products from storage. The Fort George G. Meade[1] commissary, considered one of the busiest commissaries, is no exception.

Introduction

The most visible energy consumers in the commissary are the refrigerated reach-in display cases. Lining several aisles in each commissary, vertical reach-in display cases store frozen and refrigerated foods and are directly accessible by patrons. Food products need to be kept cold while being well illuminated and highly visible.

Conventional lighting and refrigeration systems typically work against each other. Lamps and ballasts generate heat, which the refrigeration system needs to remove. In addition, lower temperatures typically reduce the efficacy of lighting systems. Thus, more power is required to generate the desired illumination, which in turn, increases the load on the refrigeration system.

Investigating ways to reduce energy consumption and costs, the Defense Commissary Agency and the Fort George G. Meade commissary sought to demonstrate a new fiber optic lighting technology in a series of vertical reach-in freezer display cases.

[1] Fort George G. Meade, located a few miles south of Baltimore, Maryland, is home to the fourth largest workforce of Army installations in the continental United States. Fort Meade's work force has approximately 39,000 members, composed of military, civilian and contractor personnel. The local population is estimated to be 109,000 in addition to thousands of daily visitors.

The reach-in freezer cases are kept between -5°F to -10°F and are used to display a variety of frozen foods from quick preparation meals to ice cream. The vertical reach-in display cases used in the demonstration line the entire length of two aisles, and include a total of 79 access doors. The lighting system consisted of 87, F40T-8 (60-inch) fluorescent lamps with customized electronic rapid-start ballasts.[2] The operation of the lights is regulated by a digital control system. The operating hours vary based on the day of the week but average 94½ hours per week.

Side-by-side comparison (fiber optic on left, fluorescent on right). The higher color temperature of the fiber optic lights may provide a perception of improved overall brightness.

Fiber Optic Lighting System

To reduce energy consumption, the old fluorescent lighting technology was replaced with a new system that uses fiber optics. The fiber optic lighting system uses a remote source light. The light is channeled into a fiber optic distribution system and emitted into the space by an illuminator. The illuminator uses optics designed to match the application to illuminate the product. In this demonstration, the Energy Focus[3] EFO-ICE™ system was installed. The new lighting technology uses a 70-watt metal halide lamp as a source light. From each source light, up to six fiber-optic cables are used to transfer the light to the vertical reach-in display freezer cases. The source lights are mounted on top of the vertical reach-in freezer cases. The fiber optic cables are routed through the top of the display cases through rigid conduit designed to prevent kinks in the fiber (if the fiber bends too sharply, light transmission can be significantly reduced). Inside the display case, the fiber optic cable connects to an illuminator, which distributes the light. An illuminator is installed on each side of a door. In general, one 70-watt metal halide lamp replaces three to four F40-T8 (40-watt) fluorescent lamps. The fiber optic lighting system offers several advantages over the fluorescent lighting system.

- The new fiber optic lighting system requires less overall power and energy. Measured lighting power was reduced to 2281 watts from 4968 watts, a reduction of 54%.
- The new metal halide lamp fixtures are located on top of the reach-in freezer cases. This provides easier maintenance access to the lamps and ballasts. It also removes the heat source from the refrigerated space.
- There are fewer lamps to maintain. With the previous fluorescent lamps, there were always a number of lamps burned out.
- Fluorescent lamps, while normally an efficient light source, have reduced efficacy in low-temperature environments. Because the metal halide light source is located outside of the refrigerated space, the efficacy remains high.
- The new metal halide lamps deliver a different color corrected temperature (CCT) compared to the standard fluorescent lamps; 6000K for the metal halide compared to 3500K for the fluorescent lamps.[4]

The refrigeration systems serve as another source of energy savings. The previous fluorescent lighting system created a high heat load for the refrigerant system. The location of new metal halide lamps and ballasts outside of the refrigerated space reduces the heat load on the refrigeration system. To see if the impact on the refrigeration system was measurable, the lights and refrigeration system were submetered as part of a demonstration activity supported by the Department of Energy, Federal Energy Management Program. The existing system was monitored for 3 months before the fiber optic lighting system was installed in the reach-in freezer display cases. The new

[2] Ardco EcoTronic™ electronic rapid start ballast, model number 2/40ET-T/120V/LTHP, catalog number C15724 P8, 2-lamps per ballast, low temperature, 120-volt, 1.02 amps, power factor is 0.96 or above. Rated input power is approximately 117.5 watts (per ballast).

[3] Energy Focus, Inc., formerly Fiberstars, Inc. (www.energyfocusinc.com)

[4] The Defense Commissary Agency design standard currently specifies 3500K lamps.

lights and refrigeration system were then monitored for an additional 2 months after the installation.

While the reduction to the refrigeration load should have been measurable, no reduction in refrigeration power or energy was observed. The lighting heat load on the refrigeration system was reduced by around 5-kW for an average 13½ hours per day. The refrigeration system serving the series of reach-in freezer display cases had a typical load of around 26 to 27-kW. Preliminary estimates indicated that peak refrigeration power should have been reduced by about 3-kW (~10%) and energy consumption should have been reduced by about 43 kWh/day (~6.5%).

A number of issues may account for no measurable reduction in the refrigeration energy, such as:

- changes in product turnover or product type affecting the refrigerant load
- changes elsewhere in the system served by the same compressor rack/refrigerant system
- minimum control features or settings on the refrigeration compressor rack.

For comparative purposes, luminace measurements were taken inside a sample of four of the vertical reach-in freezer cases, both with the previous fluorescent lighting system and again after the conversion to the fiber optic lighting system. There are no set standards for illumination levels in this application, making the implication of the results subjective. Based on the light-level measurements, the illumination on the product was reduced by an average of 50%. These measurements, however, are with fluorescent lamps with the lumen output in various states of depreciation compared to metal halide lamps in new condition.

Top of vertical reach-in freezer display cases with fiber optic lighting system.

Metal halide source light with fiber optic connections.

Measurement	Before	After	Unit
Average total lighting power	4,968*	2,281†	Watts
Operating hours per day	13.5	13.5	hours
Energy consumed per year (lights)	24,346	11,178	kWh
Energy saved per year (lights)		13,168	kWh
Energy saved per year (refrigeration)		Indeterminate	
Energy saved per year (total)		13,168	kWh
Energy cost reduction per year (total)‡		$2,253	
CO_2 reduced per year		10.4	tons
Installed cost		$30,000	
Simple payback		13.3	years

* Connected power would be higher but a number of lamps are always burned out.
† Connected power includes some fluorescent lamps in different display cases.
‡ Assumes electricity cost = $0.1711/kWh. (Reference: Fort Meade FY06 Energy Management Report)

Fiber Optic Fluorescent

The plots, overlaid on the side-by-side comparison photo, show the comparative illumination and light distribution for the fluorescent (right) and fiber optic (left) lights (based on a series of 24 measurements, scale shown in center of photo in footcandles).

Compensating for the anticipated lumen depreciation of the metal halide lamps as they age, it is estimated the illumination on the product will be reduced by around 60% compared to fluorescent lamps in similar condition.

While the reduction by the numbers appears significant, the subjective appearance of the vertical reach-in freezer display cases is very close, as shown in the side-by-side photo. The perception of maintained overall brightness with the fiber optic system may be a result of the scoptopically-enhanced color from the metal halide lamps.

Conclusions

The new fiber optic lighting system for the vertical reach-in freezer display cases at the Fort George G. Meade commissary is an improvement over the fluorescent lighting system. This application takes advantage of the benefits of an emerging lighting technology and serves as an example to others. Lighting energy use decreased by 54%; illumination decreased by around 60%, with scarcely perceptible difference; maintenance requirements decreased; heat decreased. The fiber optic lighting system allows the Defense Commissary Agency to reduce energy consumption and costs, which assists in achieving the agency's mission and goals.

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